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# Environmental Microbiology

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## Examining the soil beneath our feet

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Many environmental molecular biology studies begin with purified DNA and RNA extracted from the soil.

Overview of Research and Highlights

Learning about microorganisms—bacteria, algae, and fungi—is essential to understanding how living things interact with their environments. Exploration of environmental microbiology at Los Alamos crosses broad scales of investigation that span from identification of genetic regulatory systems in single microorganisms to comprehensive studies of the complex microbial communities resident in soil, water and air.

The long term goals of this research are to understand microbial processes and interactions, and the genomic traits underlying these activities, toward:

- Improving our ability to detect emerging pathogens in the environment and natural reservoirs
- Understanding the cellular processes of individual microbes and complex mixed microbial communities toward understanding what regulates their individual or collective activities
- Manipulating microorganisms and environmental microbial communities to produce useful products and better manage Earth's natural resources.

Our investigations couple a variety of molecular approaches in a systems biology format:

- DNA- and RNA-based
- 'omics including targeted and shotgun metagenomics, metatranscriptomics, proteomics
- microbial biochemistry and physiology

Environmental studies are tightly coupled with activity and geochemical measures, model development and statistics.

*Single organism studies* focus on bacteria, algae and fungi that are relevant to environmental processes in nutrient cycling, climate change response, contaminant fate and transport, as well as biofuels and antibiotic development.

*Complex community studies* span multiple applications from determining natural environmental reservoirs for pathogens and closely related species, to understanding the interactive roles and contributions of diverse soil bacterial and fungal communities in nutrient cycling, and climate change.

#### Single organisms

- Bacterial gene regulation: John Dunbar
- Bacterial-Iodine interactions: Chris Yeager
- Algal gene regulation: Chris Yeager
- Bacterial genome comparisons: Jean Challacombe

#### Environmental detection and microbial ecology

- Environmental detection of target organisms in soil, water, air: Cheryl Kuske & John Dunbar
- Soil communities, carbon cycling, and climate change in terrestrial ecosystems: Cheryl Kuske

#### Climate Change Research and Bioenergy Development

- Development of 'omics approaches to identify key soil bacterial and fungal populations in soil carbon cycling in forest and arid land ecosystems, (b) determination of genes and enzymes through which those populations process soil carbon, (c) the influence of anthropogenic N deposition on these processes, and (d) design of scalable molecular assays toward improved input for soil process models.
- Coupling algae sequence information with transcriptomics, proteomics, and metabolomics data to understand the biochemistry of high lipid production and to best inform decisions on feedstock choices for biofuel development

#### Molecular and 'Omics Technology Development

- DNA & RNA preparation from environmental samples: Cheryl Kuske & John Dunbar
- PCR primer set design from complex datasets: Jason Gans
- Genomics and metatranscriptome analysis/computation: Jean Challacombe
- Meta 'omics approaches for complex soil communities: Cheryl Kuske
- Databases and classifiers for classification of target genes: Gary Xie

#### A Few Current Projects include:

*Gene regulation and molecular biology of environmental bacteria and algae.* Current projects include studies of gene regulation and expression in Burkholderia, bacterial-iodine interactions, and algal gene regulation for lipid production.

*Genomics, transcriptomics and proteomics of soil bacteria and fungi involved in terrestrial carbon cycling and climate change response.* Current projects target understudied bacterial and fungal taxa found to have critical roles in carbon cycling in forest and arid land ecosystems.

*Detection, ecology, and genomics of pathogens and their close relatives.* Current projects include development of improved approaches for extraction and stabilization

of nucleic acids from environmental samples, and ecology/genomics of *Franscisélla* species.

*Soil communities and processes in terrestrial ecosystems.* Current projects include (a) development of 'omics approaches to identify key soil bacterial and fungal populations in soil carbon cycling in forest and arid land ecosystems, (b) determination of genes and enzymes through which those populations process soil carbon, (c) the influence of anthropogenic N deposition on these processes, and (d) design of scalable molecular assays toward improved input for soil process models.

Current Research Sponsors (2013)

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- Department of Homeland Security, Science and Technology Directorate
- Department of Defense/Defense Threat Reduction Agency
- Los Alamos National Laboratory, Laboratory-Directed Research & Development

*Microcoleus vaginatus*, a soil cyanobacterium that stabilizes arid land soils and provides important carbon inputs in soils worldwide.

Some soil fungi involved in decomposition of plant material in soils.

Los Alamos National Laboratory

[www.lanl.gov](http://www.lanl.gov)

(505) 667-7000

Los Alamos, NM

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